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Title of the Invention: Magnetic core.

(SUMMARY)

[PURPOSE] To provide a small-sized and thin magnetic core provided with a coating layer which is thin but has a high isolation voltage.

[CONSTITUTION] Magnetic core comprising a troidal magnetic core base body formed by rolling a thin soft magnetic alloy strip composed in such a manner that bcc-Fe solid solution crystal particles with an average particle diameter of 500 Å or less amount to 50% or more of the texture thereof, and a paraxylylene polymeric film or a chloroparaxylylene polymeric film coating the outer peripheral surface of said troidal magnetic core base body.

Claims:

(1) Magnetic core comprising

a troidal magnetic core base body formed by rolling a thin soft magnetic strip composed in such a manner that bcc-Fe solid solution particles with an average particle diameter of 500 Å or less amount to 50 % or more of the texture thereof, and

a paraxylylene polymeric film or a chloroparaxylylene polymeric film coating the outer surface of said troidal magnetic core base body.

(2) Magnetic core according to Claim 1, wherein the thickness of the paraxylylene polymeric film or the chloroparaxylylene polymeric film is 5 to 50 μm.

(3) Magnetic core according to Claim 1 or 2, wherein the chemical composition of the thin soft magnetic alloy strip composed in such a manner that bcc-Fe solid solution crystal particles with an average particle diameter of 500 Å or less amount to 50 % or more of the texture thereof is

$(Fe_{1-a}M_a)_{100-x1-x2-x3-x4-x5-x6}A_{x1}Si_{x2}B_{x3}M'_{x4}M''_{x5}X_{x6}$ (at%),

wherein M stands for one or both of Co and Ni,

A stands for one or both of Cu and Au,

M' stands for one or more of Nb, Mo, Ta, Ti, Zr, Hf, V and W,

M" stands for one or more of Cr, Mn, Al, platinum group elements, Sc, Zn, Sn and Re,

X stands for C, Ge, P and Ga,

$0 \leq a \leq 0.5$, $0.1 \leq x1 \leq 10.0$, $0 \leq x2 \leq 30$, $0 \leq x3 \leq 30$

$0.1 \leq x4 \leq 30$, $0 \leq x5 \leq 20$, $0 \leq x6 \leq 20$, $0 \leq x2+x3 \leq 30$.

(4) Magnetic core according to any of Claims 1 to 3, wherein the width of the thin soft magnetic alloy strip is [illegible] mm or less.

Detailed Description of the Invention:

[Industrial Field of Utilization]

The present invention relates to a small-sized and thin magnetic core used in a pulse transformer for, e.g., interface, a choke for noise filters or the like.

[Prior Art]

Recently, through the advance in the field of surface mounting technique, the miniaturization in size, the reduction in thickness and the improvement in functions of electronic devices are rapidly developed. As a result, as for coil members, the development of small-sized, thin and high-performance surface mounting parts is also strongly demanded. For example, a pulse transformer for interface in ISDN is required to be made small in size, thin and excellent in high-frequency transmission characteristics. That is, said pulse transformer is required to be large in inductance, small in inter-turn capacitance, high in the degree of coupling between the input and output wirings, and so forth. Further, said pulse transformer is required to have a sufficient temperature characteristic which allows it to withstand a severe environment in use.

At present, mainly used for this purpose is ferrite; actually small-sized and thin pulse transformers which are about 3 mm in height are put to practical use. However, the magnetic permeability of ferrite is so small as about 1000 at the highest, so that in case ferrite is used for the formation of a pulse transformer, the number of turns thereof is increased in order to obtain a required inductance, as a result of which the

inter-turn capacitance thereof increases, and thus, a sufficient transmission characteristic cannot be realized, and in addition, the temperature characteristic of the magnetic permeability is low, so that the transmission characteristics are apt to become unstable, and further, it is difficult to manufacture such a ferrite product small in size, thin and high in magnetic permeability.

Recently, attention is being drawn to troidal magnetic cores comprising thin strips of a magnetic alloy - represented by ultra-microcrystal soft magnetic alloys etc. - which strips are manufactured by the use of a liquid quenching method; and said troidal magnetic cores are used as various inductance elements.

In Patent Laid-Open No. (Hei) 2-295101, there is disclosed an magnetic core for the interface transformers in ISDN, which magnetic core is composed of an ultra-microcrystal soft magnetic alloy having a magnetic permeability higher than that of ferrite. In this case, an ultra-microcrystal soft magnetic alloy thin-strip with a width of 6 mm which thin-strip has been manufactured by the use of the liquid quenching method is rolled into a shape which has an outer diameter of 14 mm, an inner diameter of 7 mm, and a height of 6 mm; and the magnetic core thus formed has excellent transmission characteristics. However, it is insufficient in respect of the inductance and the thinning or reduction in thickness of the magnetic core. In particular, with reference to the thinning, the height of the magnetic core is required to be about 1 to 2 mm.

[Problem that the Invention is to Solve]

In general, in case of a coil member using a troidal magnetic core formed of a thin magnetic metal alloy strip, it is necessary to electrically insulate the magnetic core and the winding from each other. In this connection, in case of a magnetic core for the interface pulse transformers in ISDN, according to the standard in Europe which is the strictest standard, the magnetic coil is required to have an isolation voltage of 4 kV or higher. In order to electrically insulate the magnetic core and the winding from each other, it is known to use a case type coil member in which a magnetic core is accommodated in a resin-made case and a winding is disposed thereon or to use a coating type coil member in which the outer surface of a magnetic core is coated and a winding is disposed thereon. However, in the case of the case type coil member, it is practically difficult to fabricate a core case with a thin wall of 0.2 mm or below, and further, said case type coil member is inferior in mechanical strength, so that the handling thereof is difficult. On the other hand, in the case of the coated type coil member, epoxy resin has so far been exclusively used as the coating material, but due to the fact that it is very difficult to produce a coating film which is thin and has no pin hole, the fact that, in case the coating film is made thin, the coating film portion on the edge of the magnetic core is too ununiform to obtain a sufficient isolation voltage, etc., such a coating type coil member cannot be applied to a thin magnetic core with a height of 1 to 2 mm.

Thus, it is the object of the present invention to provide

a small-sized and thin magnetic core which has a high isolation voltage through it is thin.

[Means for Solving the Problem]

The present inventors have made examination on various coating materials in order to give a solution to the above-mentioned problem, as a result of which the present inventors have found that a paraxylylene polymeric film or a chloroparaxylylene polymeric film exhibits a higher isolation voltage than that of the conventionally used epoxy resin though the former is thinner than the latter. That is, the magnetic core according to the present invention is characterized by comprising a troidal magnetic core base body formed by winding a thin soft magnetic alloy strip composed in such a manner that bcc-Fe solid solution crystal particles with an average particle diameter of 500 Å or less amount to 50% or more of the texture thereof, and a paraxylylene polymeric film or a chloroparaxylylene polymeric film coating the outer surface of said troidal magnetic core base body.

The present invention will now be described in detail. As the paraxylylene polymeric film or chloroparaxylylene polymeric film used in the present invention, for example thermoplastic resins, Palylene (trade name), manufactured by Union Carbide Corporation, U.S.A. are known. More specifically, there are the following three kinds: Palylene N (polyparacylylene), Palylene C (polymonochloroparaxylylene) and Palylene D (polydichloroparaxylylene). Films composed of these thermosetting resins, Palylene, can be formed by vacuum

deposition by the use of the palylylene vapor deposition apparatus manufactured by Union Carbide Corp., U.S.A. A paraxylylene polymeric film or a chloroparaxylylene polymeric film possesses an isolation voltage of 4 kV or higher in case it has a film thickness of several μm. In addition, it is quite rare that pin hole be caused in the film, and thus, it can be sufficiently guaranteed that said film can exhibit the isolation voltage peculiar to it.

The thickness of the coating on the outer surface of the magnetic core should desirably lie within the range of from 5 to 50 μm. If said thickness is less than 5 μm, then there is the fear that the thickness of the coating on the edge portion of the magnetic core may become ununiform, and, with the thickness of 50 μm, the isolation voltage required can be sufficiently satisfied. In particular, by setting said thickness to 10 to 20 μm, a magnetic core which is ultra-thin and has a high impedance and an excellent isolation voltage can be obtained.

Applicable or usable as the soft magnetic alloys which can each constitute the magnetic core base body of the magnetic core according to the present invention are, for example, the alloys disclosed in Patent Laid-Open No. (Sho) 63-302504, Patent Laid-Open No. (Sho) 64-39347, Patent Laid-Open No. (Hei) 1-142049, Patent Laid-Open No. 1-149940, Patent Laid-Open No. (Hei) 1-156452, Patent Laid-Open No. (Hei) 1-242755, Patent Laid-Open No. (Hei) 1-242756, etc. which have all been proposed by the present inventors; more specifically, the alloys which have the chemical composition represented by

$(Fe_{1-a}M_a)_{100-x1-x2-x3-x4-x5-x6}A_{x1}Si_{x2}B_{x3}M'_{x4}M''_{x5}X_{x6}$ (at %),

wherein M stands for one or both of Co and Ni,

A stands for one or both of Cu and Au,

M′ stands for one or more of Nb, Mo, Ta, Ti, Zr, Hf, V and W,

M″ stands for one or more of Cr, Mn, Al, platinum group elements, Sc, Zn, Sn and Re,

X stands for C, Ge, P and Ga.

$0 \le a \le 0.5$, $0.1 \le x1 \le 10.0$, $0 \le x2 \le 30$, $0 \le x3 \le 30$

$0.1 \le x4 \le 30$, $0 \le x5 \le 20$, $0 \le x6 \le 20$, $0 \le x2+x3 \le 30$.

and are each constituted in such a manner that bcc-Fe solid solution crystal particles with an average particle diameter of 500 Å or less amount to 50% or more of the texture. Of these alloys, particularly desirable as the magnetic core for pulse transformers or for noise filters are those alloys which have the composition represented by

$0 \le a \le 0.5$, $0.2 \le x2 \le 3.0$, $10 \le x2 \le 20$, $5 \le x3 \le 20$,

$0.5 \le x4 \le 10$, $0 \le x5 \le 10$, $0 \le x6 \le 10$, $10 \le x2+x3 \le 30$.

The width of the thin magnetic alloy strip used for the troidal magnetic core should desirably be 3 mm or less in view of the thinning or reduction in thickness of the magnetic core, but, since it is practically difficult to manufacture thin strips which each have a width of 0.5 mm or less, said width should desirably be within the range of from 0.5 to 3 mm. Particularly desirable is the range of from 0.5 to 2 mm.

Further, the thickness of the thin magnetic alloy strip should desirably lie within the range of from 5 to 30 μm which ordinarily can be realized by the use of a liquid quenching

method such as, e.g., the single roll method and, more particularly desirable is the range of from 10 to 20 μm, since a thin strip with a thickness in said range can be easily manufactured. The thickness of the thin strip can be evaluated, in accordance with the following equation, by weight conversion. By setting to about 50 cm the length of the thin strip to be formed, a well reproducible strip thickness can be obtained. The average strip thickness = Weight/(density × length × width).

An optimum method for the manufacture of the magnetic core according to the present invention will now be described. First, by the use of the single roll method, a thin amorphous alloy strip with a width of from 0.5 to 3 mm and a thickness of from 5 to 30 μm is rolled to form a troidal magnetic core. Next, at a temperature within the range of from 450 to 650° C which is higher than the crystallizing temperature of the amorphous alloy, the troidal magnetic core is heat-treated in an atmosphere of an inert gas such as argon gas or nitrogen gas or in a vacuum for 10 minutes to 20 hours to thereby form a texture composed mainly of an ultrafine bcc-Fe crystal particles each having a particle diameter of 500 Å or less. The heat treatment may be conducted under any condition such as in no magnetic field, in a static magnetic field or in a revolting magnetic field. Further, in case the magnetic core is to be used at a high frequency, a layer insulation film made of, for example, SiO_2 or Al_2O_3 is formed to a thickness of 1 to 3 μm on at least one of the surfaces of the thin alloy strip during the manufacture of the magnetic core, whereby the inductance of the

magnetic core is further improved, so that a desirable result can be obtained. Next, the outer surface of the magnetic core which has thus been heat-treated is coated by the use of the above-mentioned coating material; and the magnetic core according to the present invention can thus be obtained.

[Embodiment]

The present invention will now be described by reference to an embodiment thereof, but the present invention is not limited only to this embodiment.

(Embodiment) An alloy melt with a composition which comprises 1 at% (atom percent) of Cu, 3 at% of Nb, 13.5 at% of Si and 9 at% of B, the balance being substantially Fe, was quenched by the use of the single roll method, whereby a thin amorphous alloy strip with a width of 1 mm and a thickness of 20 μm was fabricated. The thin amorphous alloy strip thus obtained was rolled into a shape which had an outer diameter of 10 mm and an inner diameter of 5 mm, thus forming a troidal magnetic core. Next, this magnetic core was heat-treated in a nitrogen gas atmosphere at 550° C for one hour under the application of no magnetic field and then air-cooled down to room temperature. After the heat treatment, the formation phase and texture of the thin alloy strip constituting the magnetic core were observed, as a result of which it was found that the majority of the thin alloy strip comprised bcc-Fe ultra-microcrystal particles with diameters of about 100 to 200 Å. The outer surface of the magnetic core thus obtained was coated with a paraxylylene polymeric film or a chloroparaxylylene polymeric film (Palylene

N, C, D manufactured by Union Carbide Corp.). The thickness of the coating is as shown in Table 1, but, in said Table 1, the thickness of the coating on the edge portion of the magnetic core is also shown. Further, a winding was disposed on the magnetic core, and the isolation voltage of the coil was measured by the use of an isolation voltage tester.

[Exemplary Conventional Products]

As exemplary conventional products, troidal magnetic cores each comprising a thin ultra-microcrystal soft magnetic alloy strip were fabricated in the same manner as the manner in which the embodiment of the present invention was fabricated. The outer surfaces of the resulting magnetic cores were coated with an epoxy resin to form coating layers with thicknesses of 0.3 mm and 1.0 mm, and thereafter, the isolation voltages thereof were measured in the same manner as that in the case of said embodiment. The result of the measurement is also shown in Table 1 together with the measurement result of said embodiment..

Table 1

Resin	Film thickness	Thickness of coating on the edge porion	Isolation voltage	Remarks
Epoxy	[illegible] mm	[illegible] mm	[illegible]	Convention-al product

Epoxy	1.0 mm	0.9 mm	3,9 kV	Convention-al product
Palylene N	10 μm	9 μm	4,2 kV	Present invention
Palylene C	20 μm	15 μm	4.3 kV	Present invention
Palylene D	30 μm	29 μm	4.5 kV	Present invention

As shown in Table 1, in the case of the conventional epoxy resin, a thick coating of about 1.0 mm must be made in order to obtain the same isolation voltage as in the case of the Palylene, whereas in the case of the present invention, the thickness of the coating is sufficient if it is 10 μm. In addition, in spite of the fact that thickness of the coating is small, a sufficient coating is provided even on the edge portion, which contributes to the enhancement in isolation voltage.

[Effect of the Invention]

According to the present invention, an ultra-thin type magnetic core which is excellent in respect of the isolation voltage is obtained, so that the magnetic core according to the present invention [illegible] exhibit[illegible] higher performance than the conventional magnetic cores in case it is used in a pulse transformer for interface or a choke for noise filters.